Correspondent: O. Kusumoto
                Department of Physics
                Faculty of Science
                Osaka City University
                Sugimoto-cho, Sumiyoshi-ku
                Osaka, Japan

PHENOMENOLOGICAL STUDY OF 200 and 500 GeV/c

PROTON-PROTON COLLISIONS IN EMULSION

S. Ozaki, O. Kusumoto, M. Teranaka, K. Watanabe
            Osaka City University

                S. Kaneko
            Hiroshima University

                S. Mikamo
            INS Tokyo University

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NAL PROPOSAL

Phenomenological Study of 200 and 500 GeV/c proton-proton collisions

in Emulsion

Names of Experimenters:

S.Ozaki, O.Kusumoto, M.Teranaka and K.Watanabe - Osaka City Univ.

S.Kaneko - Hiroshima Univ.

S.Mikamo - INS Tokyo Univ.

Name of Correspondent: O.Kusumoto, Department of Physics, Faculty of

Science, Osaka City University,

Sugimoto-cho, Sumiyoshi-ku, Osaka,

Japan.

Abstract

We propose to expose two stacks of nuclear emulsion to the 200 and 500 GeV/c protons. In these stacks, the following properties are examined. 1) energy dependence of total, elastic and inelastic cross sections, 2) contribution of diffraction dissociation, 3) energy dependence of mean multiplicity, 4) character of multiplicity distribution, 5) behaviors of backward particles for which momenta and masses are determined.

PHYSICS JUSTIFICATION

The following properties of the proton-proton collisions at momenta of 200 and 500 GeV/c are examined:

1) elastic and inelastic cross sections,

2) contribution of diffraction dissociation,

3) energy dependence of mean multiplicity,

4) character of multiplicity distribution,

5) behaviors of backward particles for which momenta and masses are determined.

What tendency is observed for the cross sections at very high energy, that is, whether they decrease down to zero or approach a constant or increase like a logarithmic way with energy, is one of the basic problems[1]. Though the emulsion experiment is somewhat weak to compete with the counter experiment about this problem, the cross sections and their energy dependences are at first checked through the selected events. According to π^{-}-nucleus experiments in emulsion[2], the cross section per nucleon for diffraction dissociation increases roughly proportional to $P_{0}^{1/2}$ up to 60 GeV/c where P_{0} is the incident momentum and is amounting to ~ 1 mb at 60 GeV/c. It is pointed out by Feynman[3] that at high energy limit this process should be 10 % of the elastic one. The second purpose of the present proposal is to derive the cross sections for this process of the proton at 200 and 500 GeV/c. The energy dependence of mean multiplicity of charged particles, $\langle n^{\pm} \rangle$, is also a basic problem to consider the structure of multiparticle process[3,4]. The recent results of accelerator experiments[5] show that $\langle n^{\pm} \rangle$ seems to

have a power dependence with energy rather than logarithmic way. It is our third purpose to see this energy dependence of $\langle n^{\pm} \rangle$ for proton-proton collisions. The fourth aim is to examine whether the prong-number distributions at energies of hundreds GeV are pure Poissonian or not[1]. This gives us the information whether there exists any correlation between particles at their production stage. In recent cosmic ray experiment[6], it is reported that there seems to be some production correlation between secondaries[7]. The final is the main purpose of the present proposal. About 10 % of particles emitted backward in the proton-proton CMS should be determined their momenta by the single or relative scattering measurements. By along-the-track scanning of ~ 10 km in emulsion, ~ 3000 proton-proton collisions (collisions with free and quasi-free protons) should be detected when the cross section for PP is 40 mb (corresponding mean free path ~ 3.1 m). Among the visible prongs associated with these collisions, about 1500 prongs should be determined their momenta (these prongs have track lengths per plate more than 5 mm). The maximum momentum of a recoil proton is estimated to be ~ 1.4 GeV/c under the assumptions of $P^{*} \gg M_p$ and $P^{*} \gg P_{\perp}$ where P^{*} and $P_{\perp}$ are momentum and transverse momentum of a proton in CMS and M_p the proton mass**).

**)
Under these assumptions, the momentum of a proton in Lab. system, P, is written as,
$$P = \left\{ \frac{1}{4 M_p^2} (P_{\perp}^2 + M_p^2)^2 + P_{\perp}^2 \right\}^{\frac{1}{2}}.$$
P_{max} comes from $P_{\perp max}$. Since $P_{\perp max}$ is ~ 1 GeV/c, we have $P_{max} \sim 1.4$ GeV/c.

Therefore, all of the recoil protons among the 1500 prongs could be identified.   Since the situation of $P* \gg M$ for pions and kaons is expected not to be so different for the case of the recoil proton and the mode value of $P_{\perp}$ of pions or kaons is also expected to be relatively smaller than $P*$, the chance we can identify pions and kaons seems to be more than 50 %.   Using these results, we can examine at first the features of angular and momentum distributions for protons, pions and kaons.   Second, according to the parton model[3] or the hypothesis of limiting fragmentation[8] the longitudinal momentum distribution in Lab. system for special particles, that is, protons, pions or kaons, at fixed $P_{\perp}$ approaches a limiting one at very high energy.   The tendency to approach a limit seems to be observed at the energies produced by accelerators now available[8].   Though much more statistics are needed, at high energy and also highly inelastic limits, we could observe the parton mass[9] if the model is correct.   It is not clear at present that from where the condition of high energy and highly inelastic is satisfied.   In order to proceed the study along this line, we are preparing a Helmholtz type pulsic magnet.

In the studies aforementioned, the nuclear emulsion is essentially useful, because at the energies few hundred GeV about 10 charged particles are produced by a collision and emitted in a very narrow cone and therefore a fine spacial resolving power is generally required.

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7) C.P.Wang, Phys. Rev. 180 1463 (1969).

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Experimental Arrangement

1) Beam: Protons of 200 and 500 GeV/c.

2) Intensity: 10^4 - 10^5 protons/cm^2. We would desire two test exposure of intensities 10^4 and 10^5 and then determine the final value.

3) Emulsion: Ilford K-5 pellicle of 600 micron thick and 10 x 20 cm^2, 47 sheets/stack. Beam parallel to the 20 cm side.

4) Alignment: as accurate as possible.

Apparatus

1) Emulsion storage facilities protecting from background radiations, high humidity and high temperature.

2) Processing facilities: grid-printing, adhesion of pellicle and backing glass, developing and drying.